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Progress in the Development of High Degree Potential Coefficient Models

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Abstract

A natural extension of the recent satellite derived potential coefficient models is the development of high degree (maximum 180 or 360) expansions. Such expansions are based on the combination of the satellite derived models with terrestrial gravity data and satellite altimeter data. Such models are useful for more precise geoid undulation computations, for simulation studies involving different typed of future missions (e..g. gradiometry), and as reference fields for different types of gravimetric computations. The attention to the effect of the terrain, ellipsoidal terms, and weighting. This paper reviews the basic methods used for the high degree solutions. Various correction terms are described and recent models are discussed and compared.

1. Introduction

Potential coefficient models derived from satellite orbital analysis have been determined up to various maximum degrees depending on data coverage and data accuracy. Recent models have been complete to degree 36 and 50. The normal equations from these models can be combined with surface gravity normal equations to produce a combination of the satellite and terrestrial data. In some solutions the highest degree will be equal to the highest degree in the satellite model. In other cases the solution can be carried to a higher degree that is determined by the size of the mean anomaly cell. Certain types of combination solutions require extensive normal equation formation and solution. Other methods use orthogonality relationships to merge the satellite and surface gravity data. Several high degree potential coefficient models have been developed in the past few years. The model of Wenzel (1985) used the GEML2 potential coefficient model with $1^{o}\times1^{o}$ mean anomalies to obtain a solution to degree 200. Rapp and Cruz (1986a) used GEML2 with 1^{o} data and optimal estimation theory to develop fields to degree 250. Using 30' mean anomalies, where available Rapp and Cruz (1986b) developed a model complete to degree 360. Since 30' mean anomalies are not available on a global basis the actual frequency content of the model is geographically dependent.

High degree models can also be tailored to fit existing gravity data in a given geographic region. The fitting is necessary when inaccurate, or no, terrestrial data was used in the original development of the model. Such tailored models have been described by Weber and Zomorrodian (1988).

High degree potential coefficient models have a number of different applications. Some are: a) the calculation of reference models for gravimetric predictions; calculation of geoid undulations; model for simulation studies involving future gravity field missions; study of the global spectra of the Earth's gravity field.

2. Future Prospects

The next group of high degree potential coefficient models will depend on new satellite alone solutions, acquisition of new terrestrial data, improved satellite altimeter analysis and improved theoretical and numerical formulation of the mathematical problem.

In terms of satellite models, the GEMT1 and GEMT2 models have been or will be available (Marsh et al, this volume). The GEMT2 model will be carried to degree 50 although not all coefficients will be estimated.

An effort is underway to improve the terrestrial data base collection. Activities are continually taking place at the Defense Mapping Agency Aerospace Center and the Bureau Gravimetrique International. At Ohio State the development of updated 30' and 1^{o} mean anomaly data bases is underway. Major improvements are expected for the anomaly fields in Canada, United States, Africa, Scandinavian countries, and other regions. We now have for the first time an identification of geophysical predicted anomalies in the 1^{o} data base is available.

The altimeter analysis now being done at Ohio State will produce a more reliable set of 30' mean gravity anomalies in the ocean area. The improved analysis will have the following changes:

a) additional bias removal form the altimeter data based on an adjustment in a 4^{o}x4^{o} area using a procedure developed by Knudsen;

b) use of the Levitus sea surface topography to reduce the altimeter values to the geoid;

c) use of much denser data than used in the 1984 solutions;

d) all programs moved to the Cray XMP2/8.

In our next combination solutions we will have the following improvements over the previous Ohio State models:

a) the surface free-air anomalies will be reduced to the geoid using the g_1 correction terms calculated by Wang (1988, this volume);

b) the full error covariance matrix of the GEMTX model will be used in the adjustment process;

c) ellipsoidal harmonics will be used to for the improved treatment of terrestrial gravity data;

d) the actual adjustment will be done with 30' mean gravity anomalies formed from a merger of terrestrial, altimeter derived, and a prioi (derived from GEMTX) anomalies.

3. Conclusions

High degree potential coefficient models can be estimated form a combination of satellite and terrestrial gravity information. The new above models, now being developed, can be used with improved analysis methods and improved data collection. New models should be available to degree 360 in 1989.

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